Smart IoT for Mobility

Phase 2

François Verdier – LEAT
Frédéric Mallet – I3S/INRIA
Lise Arena – GREDEG

SIM Pluridisciplinary Partners

François Verdier – Professeur – LEAT UMR CNRS 7248

Frédéric Mallet – Professeur – I3S/INRIA UMR 7271
Marie-Agnès Peraldi-Frati – Maître de Conférences – I3S/INRIA UMR 7271

Thierry Marteu - Maître de conférences – GREDEG UMR 7321
Caroline Lequesne-Roth – Maître de Conférences – GREDEG UMR 7321
Eva Mouial – Professeur – GREDEG UMR 7321
Marina Teller – Professeur – GREDEG UMR 7321

Lise Arena – Maître de conférences – GREDEG UMR 7321
Amel Attour – Maître de conférences – GREDEG UMR 7321
Guiseppe Attanasi – Professeur – GREDEG UMR 7321
Agnès Festré – Professeur – GREDEG UMR 7321
Michela Chessa – Maître de conférences – GREDEG UMR 7321

PhDs and Post-Doc on the project

Roland Kromes, PhD DS4H since 2018
Cyril Naves Samuel, PhD CIFRE Renault since 2020
Luc Gerrits, PhD UCA since 2021

Marta Ballatore, PhD DS4H since 2019
Chris Ouangraoua, PhD Région since 2020
Tim Salem, PhD UCA (ANR SIM) since 2020
Mira Toumi, Post-Doc since 2021

Enlin Zhu, PhD UCA (ANR SIM) 2020
Ankica Barisic, Post-Doc since 2021

| SIM-1 UCA JEDI 24,9 k€ |
| SIM-2 DS4H 217 k€ |
| SIM-3 ANR 690 k€ |

What are the Blockchains ?

- Blockchains are emerging as one of the most interesting solutions for developing a more collaborative economy without any trusted third party
- A blockchain is a register, divided into blocks, distributed over all the nodes participating in this blockchain
- Blockchains are thus a distributed, decentralized and digital ledger that cannot be altered
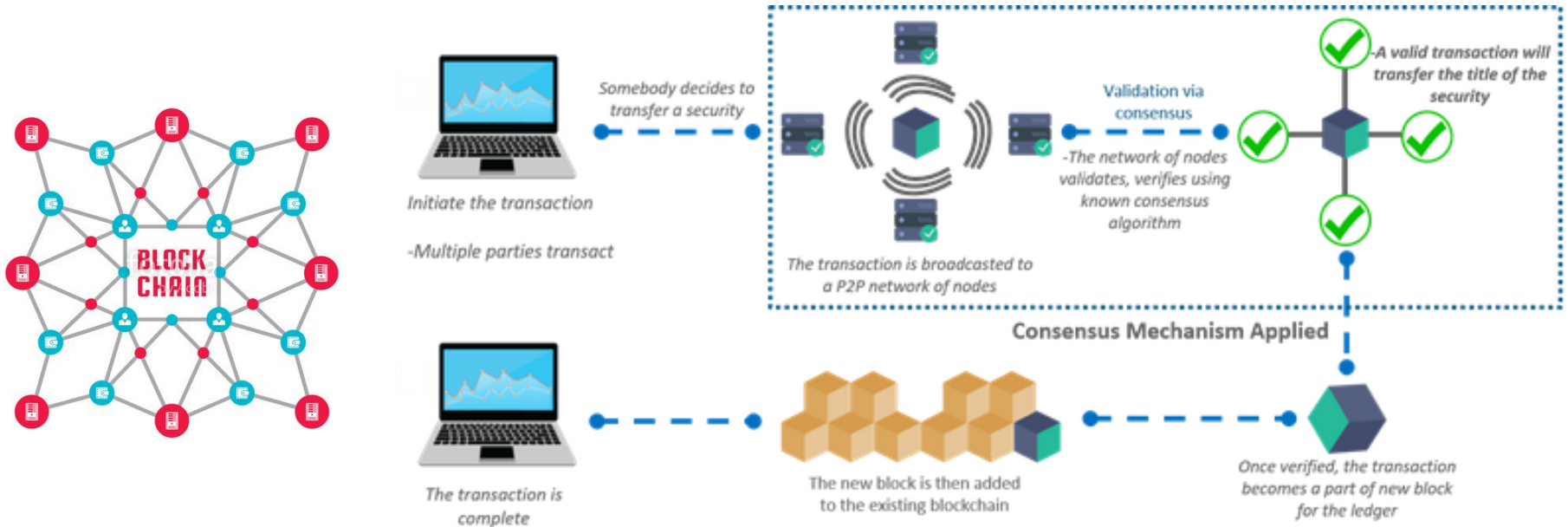
What are the Smart Contracts ?

In Blockchain 2.0, *Smart Contracts* are among the strongest innovations of this cyber-economy

- A Smart Contract is an **accessible** and **auditable** program by anyone, whose execution is **verifiable** (and therefore **verified**), coded in a **transaction** of a blockchain, designed to execute the terms and clauses of a **legal contract** and this automatically when certain conditions are verified

- The Smart Contracts can thus be understood as programs that can be **exchanged between objects**, without any intervention of anyone, and can be the only trusted « thing » between the pairs

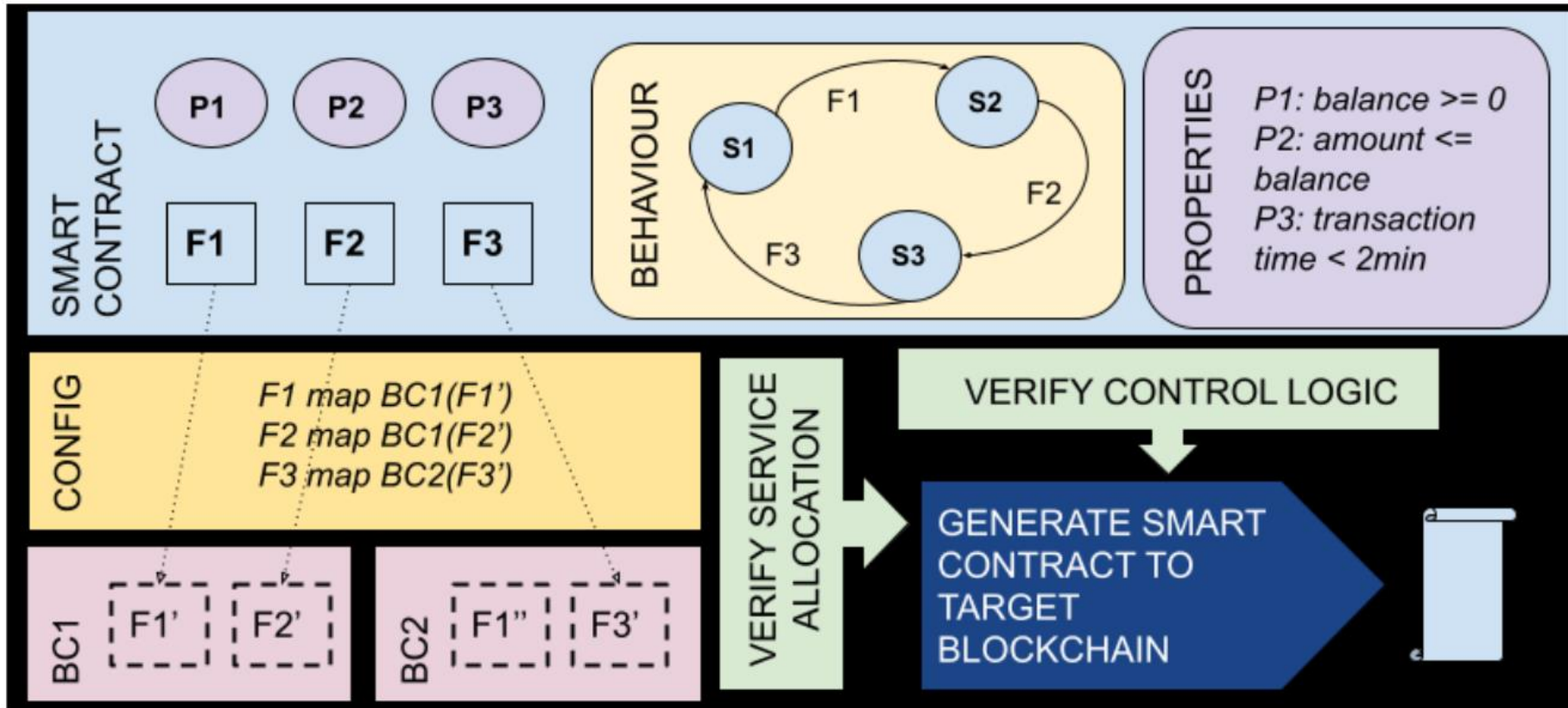- The problem is obviously to understand these programs (written in Javacript, Python, Solidity…) and to accept them !
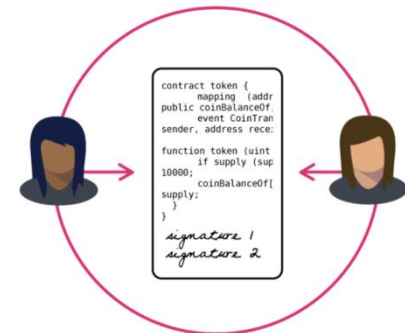
Use case: Renault Vehicle Accidentology
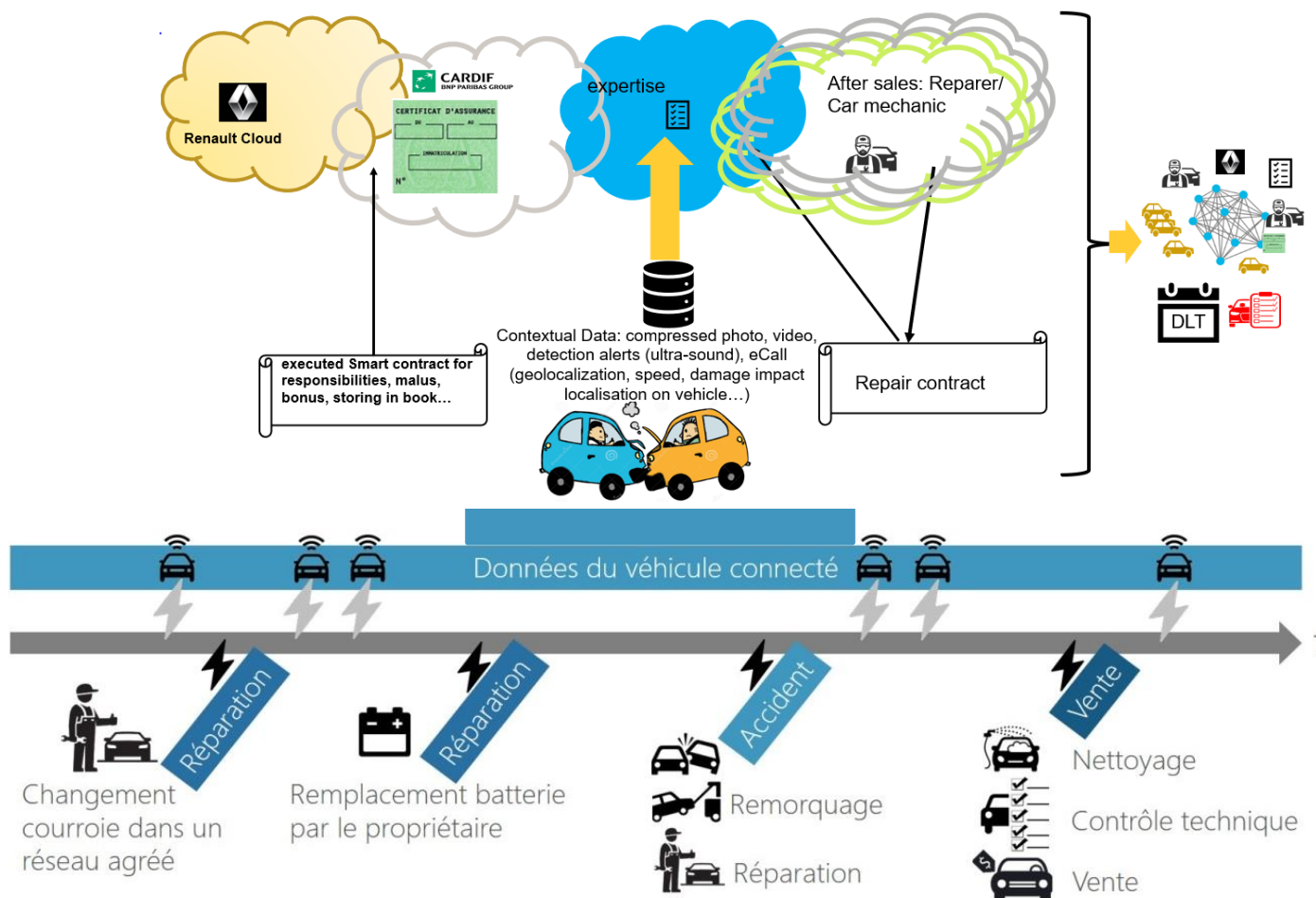
The DSLs for Smart Contracts
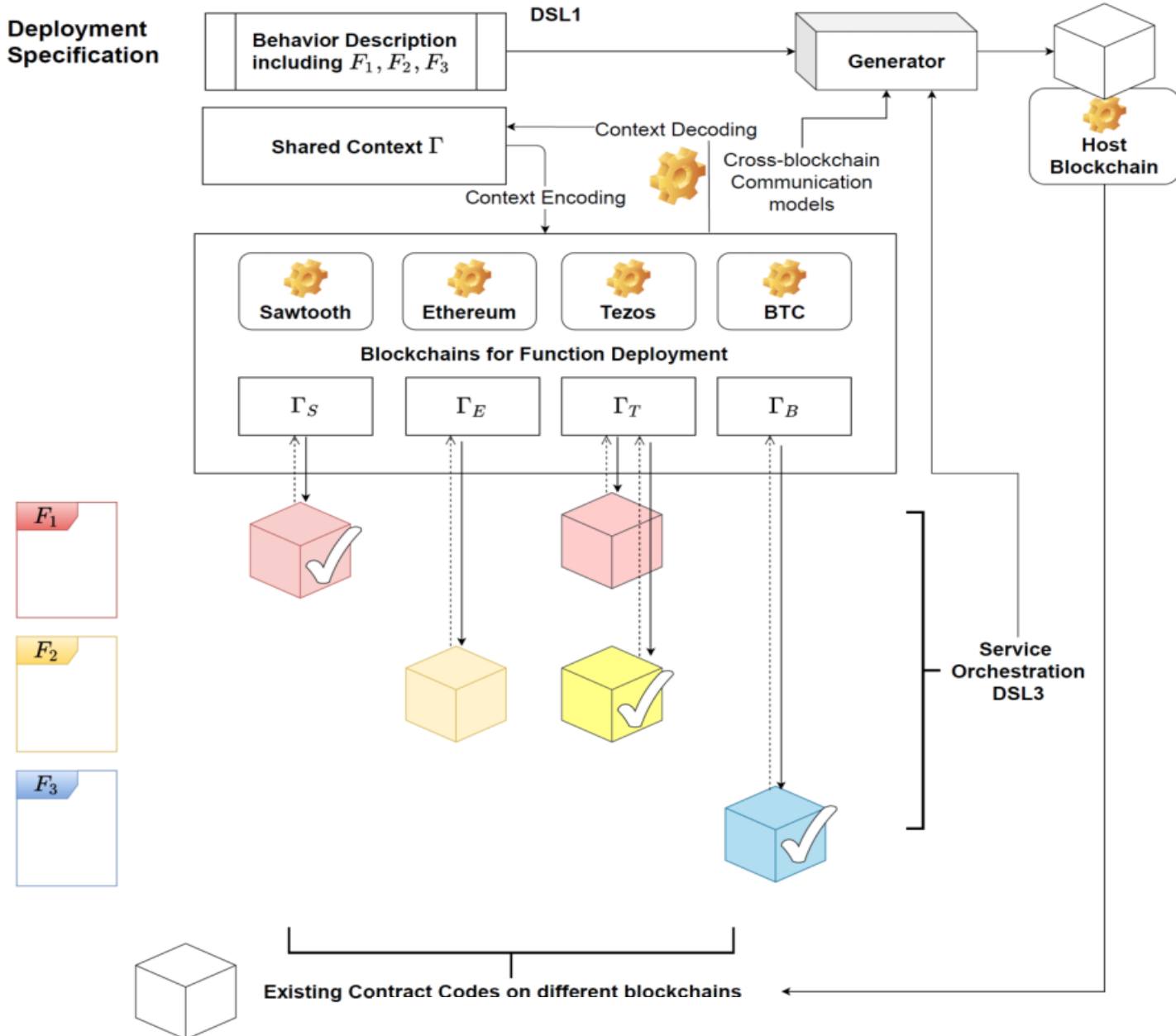
A Formal **Multi-DSL** for safe smart-contracts

Nouvelles formes d'appropriation et d'usages de technologies digitales sur le marché des objets connectés : Le cas des *smart contracts* dans l'industrie automobile

Marta Ballatore

PhD supervisors: Agnès Festré and Lise Arena

Financed by DS4H

Research doctoral stay – Aarhus University, Department of Information Systems, Denmark

Research project – Marta Ballatore

Nouvelles formes d'appropriation et d'usages de technologies digitales sur le marché des objets connectés : Le cas des smart contracts dans l'industrie automobile

The objective is twofold :

i) Identify the **uses** of blockchain technology and smart contracts ;

ii) Analyze the **possible obstacles** to these uses = TRUST

General question: The acceptability and appropriation of Blockchain and Smart Contracts technologies in the context of a connected vehicle

- *"Connected Mobility" ecosystem level* (insurers, car manufacturers, garages, banks, etc.)

- *End user level* (vehicle owner, driver)

Methodology

Interviews with experts

▪**To understand the value proposition** of blockchain technology (requirements, adoption factors) + **the role of blockchain and smart contracts** in creating trust between ecosystem players

▪Interviews : **Blockchain and business experts** from several companies at all level of the organization

At the moment :
20 hours
20 experts (CIO, marketing experts, software and hardware engineers, etc.)
10 organizations (Bank, OEMs, Start Ups)

Lab experiments

To find **behavioral characteristics** that affect users' perception of blockchain and their **intention to trust** the system or counterparties

1 experiment for end-users

1 experiment for managers

Interviews with experts

▪Blockchain could provide **distributed governance** for the costs of networking and verification

▪Blockchain is seen as an **institutional technology   providing logics and rules of intermediation between ecosystem actors**

▪ In the connected ecosystem of the vehicle, the decentralized and automatic protocol is perceived as a ***mediator*** for inter-organizational trust by guaranteeing the success of transactions

✓**However, this mediation as insufficient to provide a trustworthy ecosystem environment.**
✓Structural insurance seems to be essential to guarantee the intention of ecosystem actors to participate in its renewal

=> **The complementarity of institutional technology to traditional institutional structures (contracts, trusted third parties, judicial system) making it possible to manage the competition / cooperation tension during the renewal phase.**

Ballatore, Arena, Attour (2021) *When an Institutional IT Renews a Connected Vehicle Ecosystem: Evidence from the trust-mediator Role of Blockchain Technology,* Actes de la conference AIM 2021

Lab experiment with end-users

1) Data Collection
2) Dynamics Evaluation
3) Refund

IoT Devices Report

option A

option B
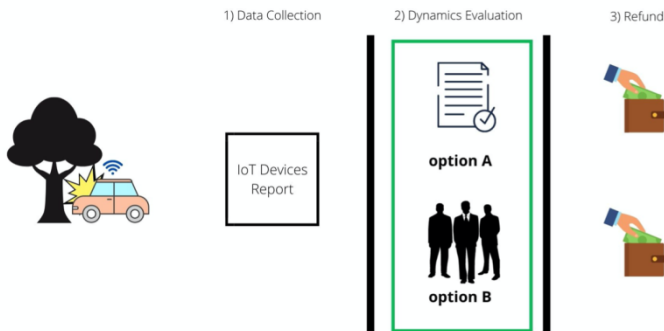
- In general, the attitude of a potential end user depends on their current experience with a vehicle (possession or use)

- *Experienced* users have a negative attitude towards the smart contract and prefer a human expert.

- *Inexperienced* users have a positive attitude

- Aversion to **ambiguity** (type of uncertainty, inability to know the probability that a result will be verified) plays a significant positive role on attitude when the user has no experience with a vehicle

- In contrast, **interpersonal trust** (generalized trust) and risk aversion (ability to calculate the probability of an outcome) play a negative role in attitude when the potential user is "experienced"

Attanasi**, Ballatore,** Chessa, Festré, Ouangraoua (2021) The Risky, the Ambiguous, and the Smart,
Under review

Preliminary results

LAB EXPERIMENT FOR INTER-ORGANIZATIONAL RELATIONSHIPS
(Lumineau et al. 2020)

What effects of a blockchain-based structure on cooperation between firms for data sharing ?

Information system

Cost reduction
Context
Manager
characteristics

Behavioral economics

Sharing
« Informational
Communs »

What role of manager's cognitive biases?

Does blockchain technology act as a mediator for inter-firms trust ?

Method

- ▪ Blockchain and business experts:
  - ▪ Survey and experiments with blockchain professionals during the Stampede event in September 2021 in Sophia Antipolis

Ballatore, Toumi, Arena (2022) "Blockchain-based data sharing system: An experimental analysis of behavioural features affecting inter-organizational cooperation", Proceedings of the 30th European Conference on Information Systems (ECIS).

Designing a Specific Low Power Architecture for Blockchain and Smart Contracts Operations in Internet of Things Platforms

Roland Kromes

PhD supervisor: François Verdier

Financed by DS4H

PhD Defended the 8th december 2021

LABORATOIRE D'ELECTRONIQUE
ANTENNES ET TELECOMMUNICATIONS

DIGITAL SYSTEMS FOR HUMANS
GRADUATE SCHOOL AND RESEARCH

UNIVERSITÉ CÔTE D'AZUR

Ratings of blockchains with IoT and Identifications of the cryptographic primitives

Studied BCs & DLTs	ethereum	HYPERLEDGER SAWTOOTH	IOTA	E O S	Substrate
Available SC	✔	✔	✖	✔	✔
Available SDK (C++)	✔ *	✔ *	✔	✔ *	✖
Hardware acceleration	SHA-256 Keccak-256 ECC Point Mult secp256k1	SHA-256 SHA-512 ECC Point Mult secp256k1	Curl Hash	SHA-256 ECC Point Mult secp256k1	BLAKE2b ECC Point Mult Ed25519
Useful for SIM ?	✔	✔	✖	✔	❓

* developed in LEAT

Results
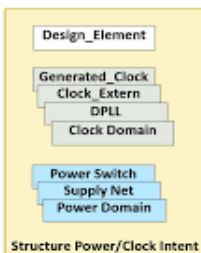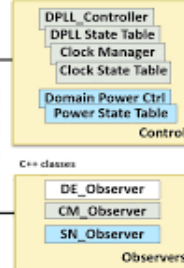
The proposed IoT hardware model with Power Management

- Running Hyperledger Sawtooth application:
  - Send a simple transaction
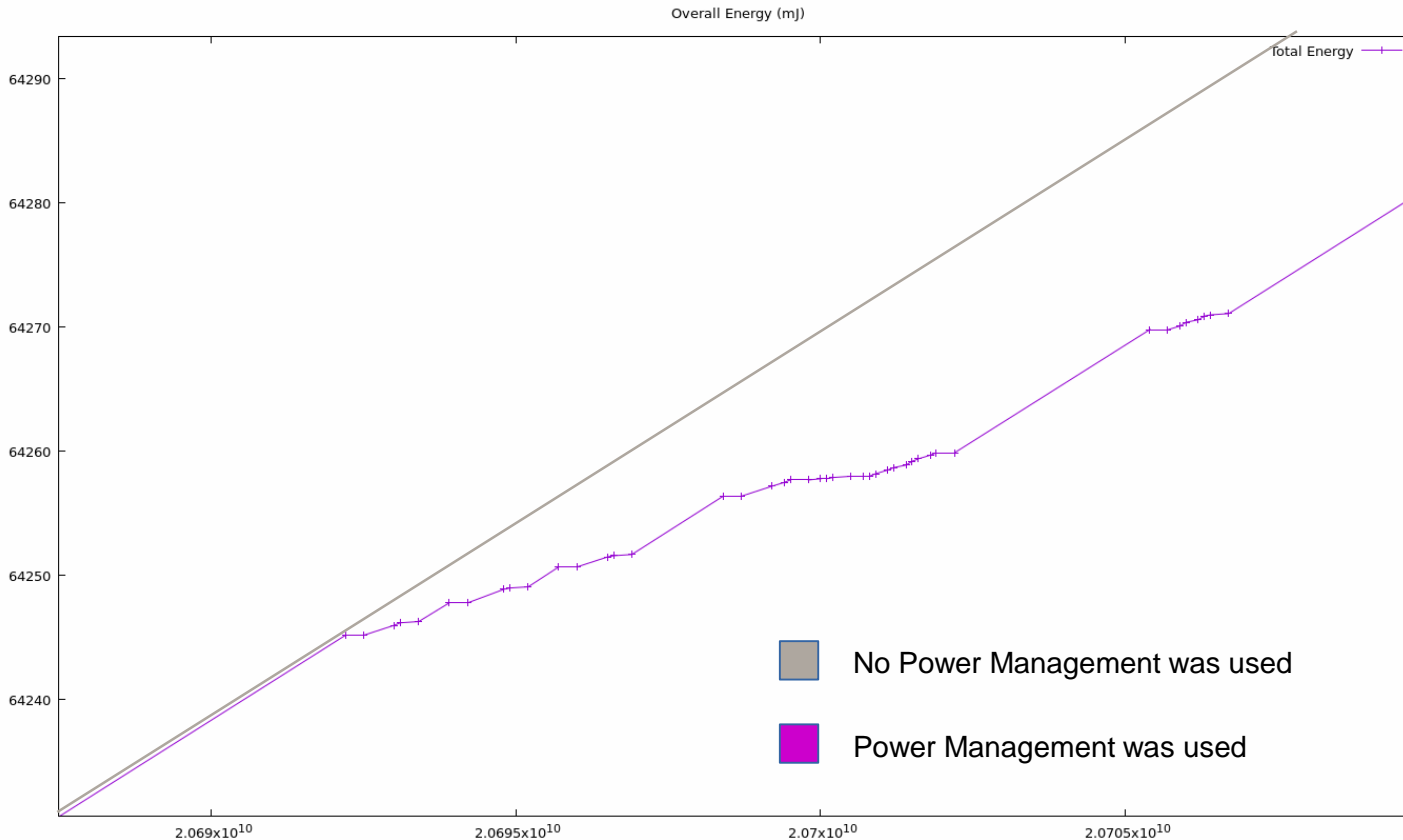
The total energy consumption (measured by PwClkARCH)

Linux/arm 5.5.0-rc5

Linux

ARM
(QEMU)

PS

Unix sockets

SystemC-TLM

PL

PS: Processing System
PL: Programmable Logic

Publications for the SIM-2 project

- **R. Kromes**, F. Verdier. *An IoT hardware modeling for using blockchain with Smart Contracts applications. 13ème Colloque National du GDR SOC2 Montpellier, Jun 2019, Montpellier, France*

- **R. Kromes**, L. Gerrits, F. Verdier. *Adaptation of an embedded architecture to run Hyperledger Sawtooth Application, 2019 IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), Vancouver, BC, Canada*

- **R. Kromes**, F. Verdier. *IoT devices hardware modeling for executing Blockchain and Smart Contracts applications. 16th ACS/IEEE International Conference on Computer Systems and Applications AICCSA 2019, ACS/IEEE, Nov 2019, Abu Dhabi, United Arab Emirates*

- L. Gerrits, **R. Kromes**, F. Verdier, *A True Decentralized Implementation Based on IoT and Blockchain: a Vehicle Accident Use Case, COINS 2020 - IEEE International Conference on Omni-layer Intelligent Systems, Aug 2020, Barcelone, Spain*

- L. Gerrits, **R. Kromes**, T. Kilimou, F. Verdier. *Hyperledger Sawtooth Blockchain for IoT-Blockchain Based Ecosystem. 14ème Colloque National du GDR SOC2 Montpellier, Jun 2021, Rennes, France*

- L. Gerrits, T. Kilimou, **R. Kromes**, F. Verdier, *A Blockchain cloud architecture deployment for an industrial IoT use case, COINS 2021 - IEEE International Conference on Omni-layer Intelligent Systems, Aug 2021, Barcelone, Spain*

- A. Barisic, **E. Zhu**, F. Mallet. *Model-driven approach for the design of Multi-Chain Smart Contracts. BRAINS 2021*

- J. Abou Faysal, N. Zalmai, **A. Barisic**, F. Mallet. *EPSAAV: An Extensible Platform for Safety Analysis of Autonomous Vehicles. MEDI / SIAS 2021*

- J. Abou Faysal, N. Zalmai, **A. Barisic**, F. Mallet : *Safety analysis of violations and inconsistencies using a formal verification tool for DSML. To appear DSC 2022*

- G. Attanasi, **M. Ballatore**, M. Chessa, A. Festré, C. Ouangraoua (2020). *The Fast, the Furious and the Smart: an experimental study on the acceptability of smart contracts in the car insurance sector. The Annual Conference SABE 2020 on Behavioural Economics*

- M. Toumi, **M. Ballatore**, L. Arena, (2021). *"An Experimental Analysis of Blockchain-based Data Sharing System in improving Inter-firm Cooperation", 11th International Conference of the French Association of Experimental Economics, ASFEE 2021*

- G. Attanasi, **M. Ballatore**, M. Chessa, A. Festré, C. Ouangraoua (2021). *The Risky, the Ambiguous, and the Smart Contract, What behavioral factors affect the end-user's perception of Blockchain-based Smart Contracts in risky decisions? Digital Economics Summer School AFRENex*

- **M. Ballatore**, L. Arena, A. Attour, (2021). *"When an Institutional IT renews a Connected Vehicle Ecosystem: Evidence from the trust-mediator Role of Blockchain Technology", Actes de la 26ème Conférence de l'Association Information et Management*

- **M. Ballatore**, M. Toumi, L. Arena (2022) *"Blockchain-based data sharing system: An experimental analysis of behavioural features affecting inter-organizational cooperation", Proceedings of the 30th European Conference on Information Systems (ECIS), forthcoming, june.*

- **M. Ballatore**, L. Arena, A. Attour (2022) *"Emerging technologies at the service of ecosystem governance: What contributions can blockchain make to new interorganizational coordination mechanisms?", 27ème Conférence de l'AIM (under review)*